

# The Natural Philosophies of Descartes and Newton: A Kuhnian Reflection

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Thomas Kuhn's *The Structure of Scientific Revolutions*<sup>1</sup> presents a radical account of the process of scientific change, and of the nature of science itself. The Scientific Revolution of the sixteenth and seventeenth centuries serves as the model of what Kuhn meant as a proper scientific revolution, and Kuhn focuses primarily on the Copernican Revolution to illustrate this point. However, this paper intends to illustrate one other transition within this period that also supports Kuhn's theory – namely, the transition between the natural philosophies of the Cartesians and the Newtonians. In particular, I would like to show how a number of concepts fundamental to each program are indicative of Kuhn's notion of incommensurability between two competing paradigms, which serve to prevent an intelligible link between both worlds.

Kuhn begins his approach to the history and philosophy of science by rejecting the commonly held view of science as continually progressing, that each scientific theory *builds* upon preceding theories, edging always closer to the truth. Kuhn sees this as far too simplistic an account of the history of science, and argues that there are radical and *incommensurable* discontinuities between different episodes of scientific investigation which make the idea of continuous progress untenable.

Kuhn sees the history of science as punctuated by radical in-

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tellectual revolutions that serve to overturn lengthy periods of mere puzzle-solving. These periods of puzzle-solving are characterized less by independent and objective research than by adherence to prescribed assumptions and expected outcomes. During these periods of so-called "normal science," curious or unexpected findings are brushed aside as irrelevant, since they do not serve to confirm or support the current system of scientific theory. Therefore, research that serves to challenge current assumptions is most often viciously attacked and debunked or ignored to the point of marginalization.

Kuhn refers to this system of dominant beliefs and assumptions as a *paradigm*. Paradigms "provide scientists not only with a map but also with some of the directions essential for map-making. In learning a paradigm the scientist acquires theory, methods, and standards together, usually in an inextricable mixture."<sup>2</sup> According to Kuhn, only results which tend to strengthen the current paradigm are accepted during periods of normal science. The paradigm itself is never criticized directly or challenged properly:

Closely examined, whether historically or in the contemporary laboratory, that enterprise seems an attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call forth new theories, and they are often intolerant of those invented by others. Instead, normal-scientific research is directed to the articulation of those phenomena and theories that the paradigm already supplies.<sup>3</sup>

However, Kuhn claims that when a paradigm fails to provide adequate explanatory force for observed phenomena, or a new, more powerful model has greater explanatory power, the paradigm reaches a *crisis* and is eventually overthrown by intellectual revolutions. Thus, there is a "paradigm-shift," in which a new paradigm literally takes the place of an old one. Kuhn writes:

the transition from a paradigm in crisis to a new one from which a new tradition of normal science can emerge is far from a cumulative process one achieved by an articulation or extension of the old paradigm. Rather it is a reconstruction of the field from new fundamentals, a reconstruction that changes some of the field's most elementary theoretical generalization as well as many of its paradigm methods and applications. During the transition period there will be a large but never complete overlap between the problems that can be solved by the old and the new paradigm. But there will also be a decisive difference in the modes of solution.<sup>4</sup>

As Kuhn illustrates, the Copernican Revolution is the quintessential paradigm shift: where an entirely new, heliocentric world-view replaced the old, Ptolemaic idea that the sun revolves around the earth. During the period of the Ptolemaic paradigm, scientists based their findings and interpretations upon the assumptions and predispositions provided by the Ptolemaic system of beliefs. Only when Copernicus – with the help of Galileo – turned these beliefs on their heads could there be a proper paradigm-shift.

Kuhn claims that paradigm shifts are similar to a religious awakening or conversion, in that one paradigm replaces another “not by deliberation and interpretation, but by a relatively sudden and unstructured event like the gestalt switch. Scientists then often speak of the ‘scales falling from the eyes’ or of the ‘lightning flash’ that ‘inundates’ a previously obscure puzzle, enabling its components to be seen in a new way that for the first time permits its solution.”<sup>5</sup> Furthermore, “once a paradigm through which to view nature has been found, there is no such thing as research in the absence of any paradigm. To reject one paradigm without simultaneously substituting another is to reject science itself. That act reflects not on the paradigm, but on

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the man. Inevitably he will be seen by his colleagues as ‘the carpenter who blames his tools.’”<sup>6</sup>

An essential aspect of Kuhn’s theory is the notion of *incommensurability*, which serves to defy the notion that science progresses necessarily towards some ultimate truth. For Kuhn, the rejection of a previous paradigm in favor of a completely new one rules out the possibility of comparison. This explains the problem that arises when two competing theories vie for the minds of the scientific community, that there is a certain breakdown of rational argument and communication between adherents of competing programs. Kuhn argues that this is because scientists working within different historical periods and different paradigms live in psychologically different worlds. As Kuhn points out, “After Copernicus, astronomers lived in a different world.”<sup>7</sup> He means that when Ptolemy observes the sun, he observes an object that moves around the earth, whereas Copernicus sees the central star of the solar system – their viewpoints are fundamentally incommensurable, in that the word “sun” means something entirely different within each paradigm. Supporters of either the Ptolemaic or heliocentric theories simply cannot argue in rational terms, since they are unable to argue about the *same thing* – they each speak a different language with a different conceptual vocabulary:

the Copernicans who denied its traditional title ‘planet’ to the sun were not only learning what ‘planet’ meant or what the sun was. Instead, they were changing the meaning of ‘planet’ so that it could continue to make useful distinctions in a world where all celestial bodies, not just the sun, were seen differently from the way they had been seen before.<sup>8</sup>

Therefore, for Kuhn, there exist deep conceptual gaps between competing paradigms in science. Despite the fact that a scientist can learn a new lexicon and become “bilingual” between two competing paradigms, there is still no way of direct translation

between them. As a consequence, one often has to use non-rational means of persuasion in order to convince an adherent of one paradigm to adopt another.<sup>9</sup>

For Descartes' mechanical philosophy, "everything in nature is to be explained in terms of the size, shape, and motion of the small parts that make up a sensible body."<sup>10</sup> Indeed, Descartes would grant no other properties to matter than extension and motion, and he essentially reduces all mechanics and physics to a geometry of motions. In essence, Descartes' mechanical philosophy treats the whole world as if it were a collection of machines, as he outlines in the *Principles of Philosophy*:

I have described this earth and indeed the whole visible universe as if it were a machine. I have considered only the various shapes and movements of its parts.<sup>11</sup>

I do not recognize any difference between artifacts and natural bodies except that the operations of artifacts are for the most part performed by mechanisms which are large enough to be easily perceivable by the senses – as indeed must be the case if they are to be capable of being manufactured by human beings. The effects produced in nature, by contrast, almost always depend on structures which are so minute that they completely elude our senses.<sup>12</sup>

Men who are experienced in dealing with machinery can take a particular machine whose function they know and, by looking at some of its parts, easily form a conjecture about the design of the other parts, which they cannot see. In the same way I have attempted to consider the observable effects and parts of natural bodies and track down the imperceptible causes and particles which produce them.<sup>13</sup>

In keeping with his mechanical conceptualization of the world, Descartes even goes as far as to claim that the human body is “nothing but a statue or machine made of earth, which God forms with the explicit intention of making it as much as possible like us.”<sup>14</sup> Therefore, as mechanics subsume physics, “*everything* in physics now receives a mechanical explanation, that is to say, everything is explained as if it were a machine.”<sup>15</sup>

Cartesian mechanical philosophy adhered to a form of corpuscularism in order to explain the nature of physical objects in the world. This view is closely related to atomism in that it claims that all physical objects – indeed, the entire universe – were composed of small corpuscles of various sizes, although corpuscles were seen as infinitely divisible, rather than being theoretically indivisible on the atomic account. What was unique in Descartes’ interpretation of the physical world was that he claimed that there could be no void between particles. Instead, Descartes argued that all matter was constantly swirling to prevent a void as corpuscles moved through other matter, thus the notion of a “vacuum” was a meaningless term. *Le Monde*, or *The World*, presents a corpuscular account of the universe in which swirling vortices explain the creation of the solar system and the circular motion of planets around the Sun, among other phenomena. In *The World*, Descartes states that

when a body leaves its place, it always enters into the place of some other body, and so on to the last body... Thus there is no more a vacuum between bodies when they are moving about than when they are at rest. And note here that in order for this to happen it is not necessary that all the parts of bodies moving together should be arranged exactly in a ring, as in a true circle.<sup>16</sup>

In light of this view of the physical world, Descartes attempted to explain the apparent “force” that causes objects to “fall” towards

the center of the earth, obviously referred to as “gravitational force” today. Garber highlights the importance of Descartes’ interpretation of gravity as a mechanical process:

If *everything* in nature is to be explained as if it produced effects like a machine, then gravitation cannot simply be *assumed*; gravitation *itself* must also be explained, and, within the *mechanical* philosophy, it must be explained *mechanistically*. Or, to put it another way, when mechanics subsume physics, we can no longer appeal outside of mechanics to some distinct science to supply necessary premises concerning heaviness: the premises necessary for doing the traditional mechanics of heavy bodies must come from within the mechanical philosophy itself.<sup>17</sup>

In keeping with his notions that space is entirely composed of various particles, that movement through space is merely a displacement of some particles with others, and that particles are interpreted only in terms of size, shape, and motion, Descartes claims that objects do not *fall* towards the earth as a result of any gravitational *pull*. Instead, he claims that the tendency to fall toward the centre of the earth is a result of an “interaction between a body and a vortex of subtle matter that turns around the earth...bodies are pushed towards the centre of the earth by colliding with the particles of subtle matter in the vortex,”<sup>18</sup> and that “power which the individual particles of celestial matter have to move away from the centre of the earth cannot achieve its effect unless, in moving upwards, the particles displace various terrestrial particles, thus pushing them and driving them downwards.”<sup>19</sup> His notion of *heaviness* is summarized as follows:

All the subtle matter which is between here and the moon rotates rapidly round the earth, and pushes towards it all the bodies which cannot move so fast. It pushes them with greater force

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when they have not yet begun to fall than when they are already falling; for after all, if they are falling as fast as it is moving, it will not push them at all, and if they are falling faster, it will actually resist them.<sup>20</sup>

Therefore, Descartes' conceptualization of "gravity" is provided in terms of size, shape, and motion alone, and fits within his general conceptualization of the world as fully consisting of various particles. In light of this, it is unsurprising that the Cartesian interpretation of gravity is based solely on the collision between a heavy body and the particles of subtle matter. These are mechanical processes, in that they are explained "in terms one uses in explaining the behavior of a machine. In this way the (spring-driven) clock or the planetary system...can be explained by Descartes strictly in terms of size, shape, and motion of their parts."<sup>21</sup>

It should be noted that Newton's account of the world is also widely regarded as one that is based on *mechanics*. However, what is important is the distinction between the term *mechanics* within the two philosophies. As mentioned earlier, Descartes' mechanics was a general view of the world as *entirely functioning as a machine*; Newton, on the other hand, viewed the term *mechanics* as it is generally used today – it is the study of *motion and the forces that change it*. Forces, in Newtonian terms, do not necessarily function in the same way as a machine, and therefore may be explained in fundamentally different ways than they can in Cartesian terms.

Newton's greatest achievement was his theory of gravity, from which he was able to explain the motions of all the planets, including the moon. Newton proved that every planet in the solar system at all times accelerates towards the sun, and that the acceleration of a body towards the sun is at a rate inversely proportional to the square of its distance from it. This, of course, led to Newton's law of universal gravitation, by which every particle in the universe *attracts* every other particle in the universe with a force that is directly proportional to the product of their masses



and that is inversely proportional to the square of the distance between them. Furthermore:

If a body be attracted by another, and its attraction be vastly stronger when it is contiguous to the attracting body than when they are separated from one another by a very small interval; the forces of the particles of the attracting body decrease, in the recess of the body attracted, in more than a duplicate ratio of the distance of the particles.<sup>22</sup>

Newton claims that his theory explains:

That all bodies about the earth gravitate towards the earth, and that in proportion to the quantity of matter which they severally contain; that the moon likewise, according to the quantity of its matter, gravitates towards the earth...All bodies whatsoever are endowed with a principle of mutual gravitation.<sup>23</sup>

What is significant about this discrepancy between the two paradigms is the specific terminology or lexicon used by each paradigm in their respective accounts of gravity. Newton's explanation of gravity in terms of a *quality* of a body of mass and an *attraction* between two bodies is fundamentally at odds with a Cartesian conception of gravity. For Descartes, as Garber illustrated, when mechanics subsumes physics, we can no longer appeal beyond mechanics to some distinct science to supply the necessary premises concerning heaviness – the premises necessary for doing the traditional mechanics of heavy bodies must come from within the mechanical philosophy itself. Explaining gravitational force in terms of *attraction* does not fit within the Cartesian paradigm of explaining phenomena solely in terms of size, shape, and motion. As a consequence, Cartesian science simply could not accept Newton's "occult" idea of gravity as being an

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*attractive* force innate in bodies of mass. Considering gravity as a universal force operating over empty space inevitably led to a problem of how any force could act at a distance. For a mechanical philosopher like Descartes, nothing could act at a distance. Rather, gravity must be talked about only in terms of a mechanical process – namely, as interaction between motion and particles.

Newton also claims to have rejected the Cartesian explanation of planetary motion in terms of vortices, arguing that the Cartesian conception is missing a fundamental active principle that is essential for the perpetual motion of a vortex:

Cor. 4. ...in order to continue a vortex in the same state of motion, some active principle is required from which the globe may receive continually the same quantity of motion which it is always communicating to the matter of the vortex. Without such a principle it will undoubtedly come to pass that the globe and the inward parts of the vortex, being always propagating their motion to the outward parts, and not receiving any new motion, will gradually move slower and slower, and at last be carried round no longer.<sup>24</sup>

Newton claims that the trajectory of planets is to be explained in accordance with the Newtonian conception of gravitational force, as opposed to any appeal to vortices (as evident in the Cartesian interpretation):

The planets move in ellipses which have their common focus in the centre of the sun; and, by radii drawn to that centre, they describe areas proportional to the times of description.<sup>25</sup>

That the moon gravitates towards the earth, and by the force of gravity is continually drawn off

from a rectilinear motion, and retained in its orbit.<sup>26</sup>

For Descartes, the only cause for motion is vortices; to speak of it in any other way is to speak in essentially occult terms.

Within the Cartesian paradigm, there must be something *physical* and *sensible* between two interacting bodies to influence each other. Newton provides no such evidence:

Hitherto we have explained the phenomena of the heavens and of our sea by the power of gravity, but have not yet assigned the cause of this power... But hitherto I have not been able to discover the causes of those properties of gravity from phenomena, and I frame no hypotheses; for whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy.<sup>27</sup>

Newton rejects the Cartesian conception of vortices by instead appealing to gravitational force, but offers no *cause* of gravity – merely that gravity is a force that is proportional to the product of two masses and inversely proportional to the square of the distance between the point masses, and as mentioned earlier, he uses such anti-Cartesian terms as “attraction” to explain such a relationship. Indeed, in Newtonian natural philosophy, there is an apparent absence of *causal hypotheses* altogether.

For Newton, the *cause* of gravity is an unnecessary part of the explanation of *how* gravity operates. Instead, Newton literally turns the Cartesian methodology (the need for causal hypotheses) on its head – as well as its notion of gravity. Descartes sees “gravity” as a “push” force, while Newton views “gravity” as a “pull” or “attraction,” an inherent quality of bodies of mass. These terms used within each paradigm, and the respective approaches to scientific problem-solving are so fundamentally in-

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compatible, so *incommensurable*, that they resist any forms of translation, and thus the debate cannot be resolved by purely rational means.

In addition to rejecting the Cartesian conceptualization of planetary motion, Newton also dismissed Galileo's mechanical theory of Earth tides in general favor of the Kepler-Gilbert theory, which holds that tides are caused gravitationally, primarily by the interaction between the moon and the earth. Furthermore, Newton also rejected the Cartesian notion that all spaces are entirely filled with particles and thus, there can be no void between particles:

Cor. 3. All spaces are not equally full; for if all spaces were equally full, then the specific gravity of the fluid which fills the region of the air, on the account of the extreme density of the matter, would fall nothing short of the specific gravity of quicksilver, or gold, or any other of the most dense body; and, therefore, neither gold, nor any other body, could descend in air; for bodies do not descend in fluids, unless they are specifically heavier than the fluids. And if the quantity of matter in a given space can, by any rarefaction, be diminished, what should hinder a diminution to infinity?

Cor. 4. If all the solid particles of all bodies are of the same density, nor can be rarefied without pores, a void, space, or vacuum must be granted.<sup>28</sup>

However, if there is indeed a “fundamental conceptual gap” between the two paradigms, how is it that Newton seems to be able to argue against Cartesian mechanics so intelligibly? On the contrary, although the argument may appear to have established a bridge between the two paradigms, when given a closer examination, it only reinforces the conceptual gap between them.

In order to refute the Cartesian conceptualization of “space,” and the claim that there can be no vacuum, Newton appeals to “density,” a property of a body of matter. However, in Cartesian mechanics, there is no concept of “density.” Instead, “the nature of body consists not in weight, hardness, colour, or the like, but simply in extension.”<sup>29</sup> For Descartes, matter has no other properties other than size or three-dimensional extension. In measuring the quantity of matter, a Cartesian only relies on the measurement of the surface area or volume and the relative amount of three different sizes of particles. Bodies made up of a relatively high amount of the smallest particles are *less solid*, while those with a relatively high amount of the largest particles are *more solid*. For a Newtonian, quantity of matter is “mass,” a calculation of *density* and *volume*; for a Cartesian, the notion of “mass” is *spatial extension*, and nothing more. The “density” of particles in a body of matter has no place in the equation; indeed, “density” has no place in Cartesian mechanics. For Newton, mass is not extension, yet extension is the only inherent property of matter for Descartes. As a consequence, the Newtonian concepts of “mass” and “density” are simply incomprehensible to a Cartesian. Thus, although it appears as though Newton argues against the Cartesian claim that there can be no vacuum in space, it is only through the use of terms that are fundamentally unintelligible to the Cartesian. Newton makes no attempt to refute Cartesian mechanical philosophy using terminology within the Cartesian paradigm, only that which is conceptually outside of it, which dissolves any grounds for rational, intelligible argument.

What was particularly significant about Descartes’ program was that he set out to provide an account of natural phenomena through reason: in an *a priori*, deductive, synthetic methodology, rather than purely through examination of empirical evidence. Although there is a great deal of debate over the role of experience and non-mathematical evidence in Descartes’ natural philosophy, what seems to be clear is that Descartes held *a priori* reasoning, based on first causes or principles of nature established through geometry or mathematics, to be paramount in scientific inquiry. As Sakellariadis demonstrates, Descartes was particu-

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larly dismissive of empirical evidence presented to him by his contemporaries that served to counter his own theories:

The burden of Descartes' [letter to Mersenne of 18 December 1629] suggests that Mersenne sent him some data that seemed to refute his theory...Referring to the measured acceleration of the pendulum bob, [Descartes] wrote: "As for the magnitude, I ignore it. And even if he can make a thousand experiments to find it more accurately, I do not have to take the trouble to do them myself, if they cannot be explained by reason." No matter how clearly the results of Beeckman's and Mersenne's observations differed from the predictions of Descartes' principles, no matter how accurate or reliable the results, Descartes claimed that he was not constrained to consider them...unless the results could be adequately explained by another, more logical theory.<sup>30</sup>

Therefore, by and large, Descartes sees proper scientific theories as being derivable through *a priori* reasoning, and consequently to be held no matter what empirical evidence served to counter them. In Kuhnian terms, Descartes has become entrenched within a certain way of seeing things, in that he tends to see only that which he expects to see. Only results which tend to strengthen the current paradigm get accepted during this period of "Cartesian normal science." Indeed, it would seem as though such rigidity may have served to cloud Descartes' vision.

On the other hand, a scientific hypothesis or theory that relies primarily on empirical evidence is, on the Cartesian paradigm, simply an inadequate one. However, within the Newtonian paradigm, even the *approach* to natural philosophy is fundamentally distinct from that of the Cartesian. As Newton proclaimed during his Presidency at the Royal Society, the Newtonian

program was to reinstate the significance of empirical evidence in scientific inquiry:

Natural Philosophy consists in discovering the frame and operations of Nature, and reducing them, as far as they may be, to general Rules or Laws – establishing these rules by observations and experiments, and thence deducing the causes and effects of things.<sup>31</sup>

Newton's empirical method claimed to provide the proper description of the relevant natural phenomenon and, in light of that description, provide general principles that account for such phenomena. No *a priori* reasoning is necessary to account for natural phenomena. Indeed, the Newtonian empirical method was intended to "loosen what Newton took to be the pernicious grip of Cartesian notions within natural philosophy."<sup>32</sup> For Descartes, empirical evidence alone can neither confirm nor disconfirm hypotheses; for Newton, they are essential for both. Clearly, the two paradigms have distinctly incompatible criteria for what counts as an adequately solved scientific problem.

To reiterate, according to the mechanistic scientific program, all natural phenomena must be explained in terms of size, shape, and motion. As a result, a scientist working within this paradigm must explain all natural phenomena, such as planetary motion or trajectories and gravitational force, in terms of various collisions between small bodies making up the larger bodies of everyday experience. The idea that things operate only through the size, shape, and motion of their parts is *not* intelligible to the Newtonian as it is to the Cartesian. Within the Newtonian paradigm, such mechanical explanations are misplaced, and are entirely unnecessary. Instead, as in the case of gravitational force, one explains such natural phenomena in terms of an *attractive* force between each body in the universe. There exists a significant incompatibility between the Cartesian and Newtonian conceptions of both "matter" and "space." The *foundation* of Cartesian physics relies on the denial of the existence of vacuums or

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voids between or within particles. On the Newtonian conception, such denial does not exist; indeed, it is viewed as entirely erroneous. When a Cartesian talks of "space," his conceptualization is so fundamentally opposed to that of the Newtonian paradigm that it defies accurate comparison. "Space" for a Cartesian simply is not "space" for a Newtonian – the same goes for "matter," "gravity," and "planetary motion." Thus there are serious difficulties in directly comparing or translating these competing conceptions; in other words, these terms are fundamentally *incommensurable*.

The consequences of such a fundamental conceptual gap is great, as it is indicative of how the Newtonian system did not *build upon* the ideas of the Cartesians, but rather *reinvented* the nature of science itself – both the explanatory power of science and its limits. There was no clear progression or improvement from Cartesianism to Newtonianism. Instead, the Cartesian paradigm was quite suddenly discarded by scientists and replaced by the Newtonian worldview:

[W]hile the standards of corpuscularism remained in effect, the search for a mechanical explanation of gravity was one of the most challenging problems for those who accepted the *Principia* as paradigm...Unable either to practice science without the *Principia* or to make that work conform to the corpuscular standards of the seventeenth century, scientists gradually accepted the view that gravity was indeed innate. By the mid-eighteenth century that interpretation had been almost universally accepted, and the result was a genuine reversion...Innate attractions and repulsions joined size, shape, position, and motion as physically irreducible primary properties of matter.<sup>33</sup>

Due to these fundamental gaps between the two worldviews, the remaining supporters of the Cartesian paradigm were unable



(though, in many cases, they were quite unwilling) to change their own worldview and adopt the Newtonian program, and thus became increasingly marginalized by the scientific community. The Cartesian paradigm, rather than being acknowledged as deficient and accordingly improved upon, eventually died out with the last of its supporters. Just as Kuhn claimed, the debate between the two camps was not resolved by purely rational means such as deliberation or subtle adjustments in light of new findings. It was, rather, a relatively sudden switch creating a new, widely held, distinctly *Newtonian* worldview.

As Garber has shown, it may be inappropriate to deny the intelligible link between the Aristotelian and Cartesian paradigms. However, this is clearly not the case when analyzing the Cartesian and Newtonian paradigms. As a consequence of opposing standards for what counts as an adequately explained scientific quandary, as well as a fundamental conceptual gap between the two systems, there is no such intelligible link between the Cartesian and Newtonian paradigms, which in turn provides clear support for the Kuhnian theory of the nature of scientific revolutions.

## NOTES

<sup>1</sup> Kuhn, *The Structure of Scientific Revolutions*. 3rd Edition. Chicago and London: University of Chicago Press, 1996.

<sup>2</sup> *Ibid.*, 109.

<sup>3</sup> *Ibid.*, 24.

<sup>4</sup> *Ibid.*, 85.

<sup>5</sup> *Ibid.*, 122.

<sup>6</sup> *Ibid.*, 79.

<sup>7</sup> *Ibid.*, 117.

<sup>8</sup> *Ibid.*, 129.

<sup>9</sup> The shift from Aristotelianism to Cartesian mechanics is examined in Daniel Garber's "Descartes and the Scientific Revolution: Some Kuhnian Reflections." Garber illustrates that "there could scarcely be a more paradigmatic instance of a Kuhnian scientific

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revolution than this, the transition between one scientific paradigm and another." However, it should be noted that Garber argues that the Kuhnian model of incommensurability between two paradigms *may not* apply in this particular case. Garber claims that there is no such conceptual gap between the two paradigms, as the notion of a machine was as "fully compatible on the Aristotelian paradigm as it was on the Cartesian." Nevertheless, as it will be shown, a Cartesian-Newtonian paradigm analysis is indeed supportive of Kuhn's model.

<sup>10</sup> Garber, "Descartes and the Scientific Revolution: Some Kuhnian Reflections," 408.

<sup>11</sup> Descartes, *The Philosophical Writings of Descartes*, vol. I, Pr IV 188.

<sup>12</sup> Ibid., Pr IV 203.

<sup>13</sup> Ibid., Pr IV 203.

<sup>14</sup> Descartes, *Oeuvres de Descartes*, vol. XI, 99.

<sup>15</sup> Garber, "Descartes, Mechanics, and the Mechanical Philosophy," 192.

<sup>16</sup> Descartes, *The Philosophical Writings of Descartes*, vol. I, 86.

<sup>17</sup> Garber, "Descartes, Mechanics, and the Mechanical Philosophy," 193.

<sup>18</sup> Ibid., 195.

<sup>19</sup> Descartes, *The Philosophical Writings of Descartes*, vol. I, Pr IV 23.

<sup>20</sup> Ibid., vol. III, 135.

<sup>21</sup> Garber, "Descartes, Mechanics, and the Mechanical Philosophy," 198.

<sup>22</sup> Newton, *The Mathematical Principles of Natural Philosophy*, 173

<sup>23</sup> Ibid., 325.

<sup>24</sup> Ibid., 314.

<sup>25</sup> Ibid., 342.

<sup>26</sup> Ibid., 331.

<sup>27</sup> Ibid., 446.

<sup>28</sup> Ibid., 336.

<sup>29</sup> Descartes. *The Philosophical Writings of Descartes*, vol. I, Pr II 4.

<sup>30</sup> Sakellariadis, "Descartes's Use of Empirical Evidence to Test Hypotheses," 69.

<sup>31</sup> Newton, *Philosophical Writings*, ix.

<sup>32</sup> Ibid., xii.

<sup>33</sup> Kuhn, *The Structure of Scientific Revolutions*, 105-106.

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